# Long-term effect on foot and ankle donor site following vascularized fibular graft resection in children

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**This study was carried out to evaluate the long-term effect on the donor side of the foot and ankle following vascularized fibular graft resection in children. Eight patients underwent resection of the fibula for the purpose of a vascularized fibular graft by a surgical team who practiced leaving at least 6 cm residual distal fibula. The age of these children at the time of surgery was between 3 and 12 years. They were reviewed between 3 and 12 years after surgery. Two patients who underwent resection of the middle shaft of the fibula at 3 and 5 years of age developed abnormal growth of the distal tibia, leading to ankle valgus. They were treated with growth modulation of the distal tibial physis and supramalleolar osteotomy with tibiofibular synostosis. Another patient who underwent the entire proximal fibula resection at the age of 6 years had developed hindfoot valgus because of weakness of the tibialis posterior muscle. He required talonavicular fusion and flexor hallucis to tibialis posterior muscle transfer. Patients operated at the age of older than 8 years neither had ankle nor hindfoot deformity. We concluded that resection of the middle shaft of the fibula for the purpose of a vascularized fibula graft, leaving a 6 cm distal fibular stump in children younger than 6 years old, may give rise to abnormal growth of the distal tibial physis, leading to valgus ankle. The entire proximal fibular resection for the similar purpose in a 6-year-old child may give rise to weakness of tibialis posterior and hindfoot valgus. *J Pediatr Orthop B* 24:450–455 Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.**

**Journal of Pediatric Orthopaedics B** 2015, **24**:450–455

**Keywords: ankle, children, donor, foot, valgus, vascularized fibular graft**

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## Introduction

Resection of vascularized fibular graft (VFG) is known to be associated with muscle weakness because of disturbance of muscle origin, ankle instability because of short residual fibula and sensory deficit because of iatrogenic injury [1,2]. In adults, biomechanic and clinical studies have shown that preservation of 6–7 cm of the distal fibula produced good foot and ankle function in most individuals [3–5]. Another study showed that 10% of fibula left is adequate for ankle stability [6]. Most of these studies focused on the ability of distal fibular and its associated structures to provide ankle stability by studying the demonstrable talar tilt. Unlike in adults, VFG resection in children is associated with long-term valgus deformity of the ankle that relates to abnormal growth of the distal tibial physis [7,8]. This study was carried out to determine the contributing factor to abnormal growth of the distal tibial physis following VFG resection in children.

### Methods

We reviewed eight children who had undergone VFG resection by a surgical team between 1999 and 2011 at our institution. The team had practiced leaving a minimum of 6 cm distal fibular stump. We determined the age at onset of surgery and the residual length of the fibula base from surgical notes and radiograph records. Growth abnormalities were assessed on the basis of records as well as assessment of the most recent clinical appearance and standing radiographs.

## Results

The patients were between 3 and 12 years old at the time of surgery. They were reviewed between 3 and 12 years later. In all cases, the distal fibular stumps were recorded to be more than 5 cm in length.

Two patients (no. 1 and no. 2) who underwent middle shaft of fibula resection at the age of 3 years developed ankle valgus deformity. In patient no. 1, the ankle valgus deformity was treated at the age of 10 years with a guided growth procedure (Fig. 1), whereas in patient no. 2, it was treated at the age of 14 years by supramalleolar osteotomy (Fig. 2). Both these patients underwent an additional procedure of creating distal tibia–fibular synostosis.

Patient no. 3, who underwent ipsilateral vascularized fibula transfer to the tibial gap at the age of 3 years, with a rush rod transfixing the ankle, did not develop valgus deformity (Fig. 3).

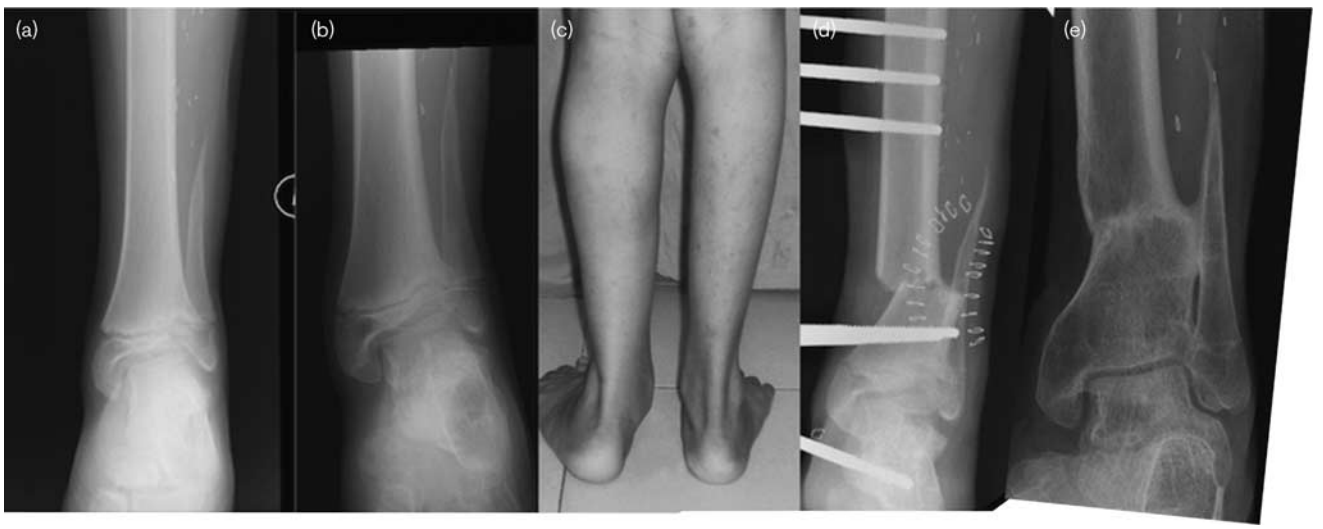
Patient no. 4, who underwent the whole proximal tibia resection at the age of 6 years, presented with flat foot and hindfoot valgus without obliquity of the ankle joint at the age of 16 years. The tibialis posterior muscle was


DOI: 10.1097/BPB.0000000000000197

**Fig. 1**


Patient no. 1: (a) ipsilateral vascularized fibular graft transfer to treat bone loss following osteomyelitis at the age of 3 years. (b) Valgus ankle at the age of 10 years with evidence of hypertrophy of the lateral cortex of the tibia. (c) Medial-guided growth procedure and creation of tibiofibular synostosis at the age of 10 years. (d) Improvement in the ankle after 1 year.

**Fig. 2**

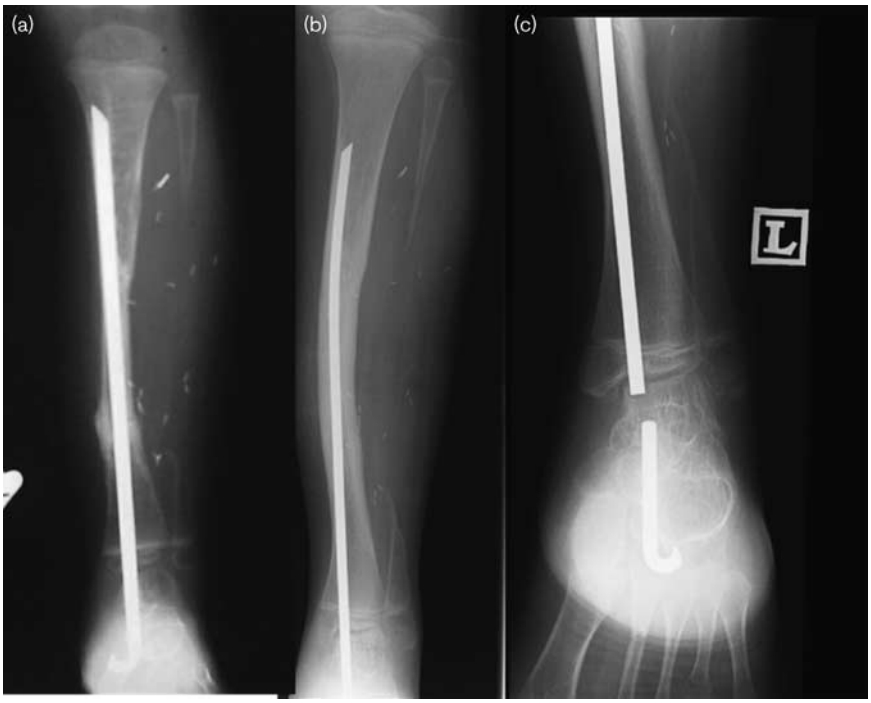



Patient no. 2: (a) resection of the fibula at age of 5 years. (b, c) Valgus ankle 6 years later. (d) Supramaleolar osteotomy and creation of distal tibia–fibula synostosis at the age of 14 years. (e) Improvement in the ankle after 1 year.

clinically documented as Medical Research Council grade 3. He underwent calcaneal osteotomy, talonavicular fusion and transfer of the flexor hallucis longus to the tibialis posterior muscle to treat hindfoot valgus (Fig. 4).

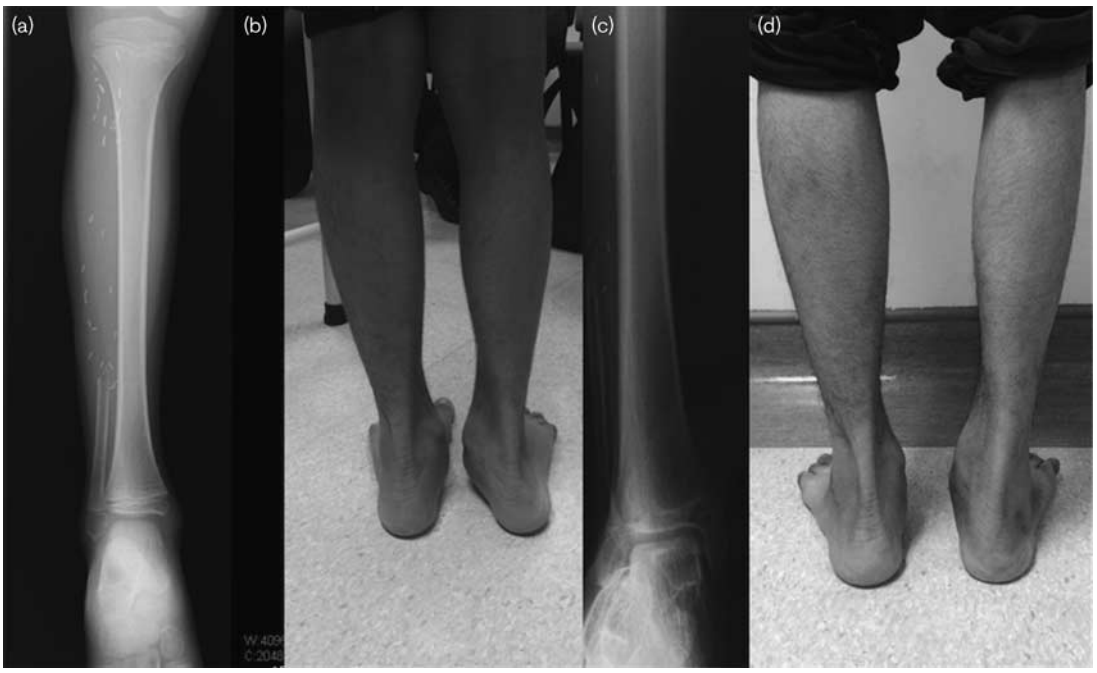
Patient nos. 5, 6, 7 and 8, who underwent either middle shaft or proximal tibia resection between the age of 9 and 12 years, had neither growth abnormality of the distal tibia nor muscle weakness (Fig. 5, Table 1).

**Fig. 3**




Patient no. 3 underwent ipsilateral transfer of the fibula to fill the gap following resection of CPT at the age of 3 years. (a) Intramedullary nail inserted to treat distal junctional nonunion at 6 months following the transfer. (b) A longer nail was inserted at the age of 7 years with the ankle remaining horizontal. (c) Ankle remained horizontal at the age of 15 years with the broken nail at the ankle joint.

**Fig. 4**




Patient no. 4: (a) resection of the proximal fibula at 6 years of age. (b, c) Valgus of the hindfoot without ankle deformity noted at the age of 16 years. (d) Deformity-corrected foot after surgery.

**Fig. 5**


Example of a standing radiograph without ankle deformity at 9 and 10 years after surgery. (a) Patient no. 5, who underwent resection of the middle shaft fibula at 12 years of age. (b) Patient no. 6, who underwent resection of the proximal fibula at 9 years of age.

## Discussion

This study focused on the long-term effect of VFG resection on the ipsilateral ankle that is related to abnormal growth of the distal tibial physis in children.

The fibula carries one-sixth of the static load of the leg and transmits it through the talus [9]. Resection of the vascularized fibula graft in the shaft will leave a huge permanent bone gap in the fibula. The stability provided by the fibula would then depend on the tibia–fibula connection through the interosseous membrane that is related to the distal fibular stump and the inferior talo-fibular ligament. In this study, patients who were younger than 6 years old (no. 1 and no. 2) developed abnormal growth distal tibia; however, those older than 9 years at the time of surgery did not develop the deformity. This is consistent with a few other studies [7, 8,10,11]. Nanthan *et al.* [12] showed that valgus deformity occurred in a 6-year-old patient when the length of the residual fibula measured about 6 and 7 cm on the basis of the given age–residual fibula index. Valgus deformity also occurred in a 10-year-old patient with a residual fibula length of less than 5 cm. Thus, they suggested that ankle valgus was predicted to develop in patients with

**Table 1 Details of patients with fibular resection**

| Patient number | Age at surgery (years) | Diagnosis and (segment of fibular resection) | Residual length of the fibula (cm) | Resected segment of the fibula (cm) | Donor-site morbidity (period of review from surgery) |
|---|---|---|---|---|---|
| 1 | 3 | Left tibia segmental defect secondary to chronic osteomyelitis (middle segment) | 6 | 7 | Valgus ankle (6 years) |
| 2 | 5 | Congenital pseudarthrosis of right tibia (middle segment) | 6 | 13.5 | Ankle valgus (9 years) |
| 3 | 3 | Congenital pseudarthrosis of left tibia (ipsilateral middle segment but ankle transfixed with rush rod) | 6 | 11 | No deformity (12 years) |
| 4 | 6 | Osteosarcoma of the left radius (proximal fibula) | 6 | 15 | Hindfoot valgus with weak tibialis posterior muscle (10 years) |
| 5 | 12 | Osteosarcoma left distal femur (middle segment) | 5.5 | 21.5 | No deformity (9 years) |
| 6 | 9 | Osteosarcoma of left distal end radius (proximal fibula) | 8.5 | 19 | No deformity (10 years) |
| 7 | 12 | Osteomyelitis of tibia (middle segment) | 7 | 19 | No deformity (3 years) |
| 8 | 12 | Congenital pseudarthrosis of left tibia (middle segment) | 6 | 21.5 | No deformity (9 years) |

the age–residual fibula index (age in years plus residual fibular length in centimetres) less than 16 [12].

We could not conclude when the deformity started to occur as this review was performed about 3–12 years after surgery. However, Nanthan *et al.* [11] found that the deformity started to occur between 20 and 38 months after resection.

There are a few possible interrelated factors in terms of what had occurred in these very young patients. The first one is the obliquity of the ankle mortise in a normal child before the age of 10 years [7]. The second reason is that younger children have more lax ligament. Thus, the effect of absence of fibula continuity would result in significant instability to their ankle, which eventually leads to greater load distribution to the lateral distal tibial growth plate. Unfortunately, early valgus stability assessments were not performed in our patients to provide a definitive answer. However, increased bone density on the lateral cortex of the distal tibia as shown in patient nos. 1 and 2 indicated an uneven load distribution across the growth plate of the distal tibia. These conditions led to growth impairment as a previous experiment has proven that excessive pressure applied to the growth plate inhibits growth [13,14]. Impairment of growth on the lateral side will worsen the obliquity of the ankle, leading to vicious cycles of instability, abnormal load distribution and progressive valgus deformity.

A more rapid growth of the distal tibial physis at a young age, before achieving 50% eventual tibial length [15], could be another possible explanation for distal tibial growth abnormality in patients younger than 6 years old.

Different from the first two patients, deformity occurred at the subtalar region in patient no. 4, who underwent proximal fibular resection at the age of 6 years. This was associated with weakness of the tibialis posterior muscle because of loss of the proximal anchor of the muscle following resection of the proximal fibula. The ligamentous laxity and ankle obliquity would worsen the subtalar valgus deformity. Distal tibial physeal growth abnormality was observed in this patient possibly because of the longer distal fibular stump and minimal growth of the distal tibial physis at this age. However, although it is known that older children will have minimal distal tibial growth, we could not conclude whether the age of 6 years was the cut-off point. To our knowledge, there has been no report on the resection of VFG complicated with weakness of the tibialis posterior muscle, which serves as a strong support to the medial side of the foot. Weakness of long flexor of the toes, toes extensor and peroneus muscles has been reported following fibular graft resection in adults; however, there is no detailed information on whether the weakness occurred in proximal or middle segment resection [1,2]. Theoretically, proximal resection would have a longer residual distal fibular, and thus leads to a lower risk of ankle problem, but a possible risk of knee instability. However, similar to the finding of Babulkhar *et al.* [2], we did not encounter knee instability following proximal fibular resection in our patients.

Stability of the ankle may prevent the occurrence of valgus as proven by the presence of an intramedullary nail across the ankle inserted at the age of 3 years in patient no. 3. However, ankle transfixation is not a routine procedure to prevent progressive valgus of ankle because of its potential morbidity. Therefore, we suggest that a prophylactic distal tibiofibular synostosis as a possible method to prevent progressive valgus deformity if the surgery is performed in patients younger than 6 years old with residual distal fibular of less than 7 cm length. Bauer *et al.* [16] performed distal tibiofibular fusion or the Langenskiöld procedure following fibular graft resection in five children, resulting in no complaint of ankle pain instability in any child. Nanthan *et al.* [12] suggest close monitoring and correction when a deformity becomes obvious. Babulkhar *et al.* [2] treated ankle instability using a sliding graft from the proximal remnant fibula to bridge the gap. This technique would require adequate length of residual fibula to fill the gap.

Once valgus ankle deformity has occurred, it can be treated with a growth modulation procedure when there is residual growth for a few years [8]. Bowen *et al.* [17] found that epiphyseal stapling can correct the distal femur at the rate of 7 and 5 degrees a year in the distal femur and the proximal tibia, respectively. Stevens *et al.* [18] reported a faster rate using a nonlocking extraperiosteal two-hole plate with screws compared with stapling and there has been no permanent growth arrest. We successfully treated patient no. 1 using this method. The correction of the deformity using this method is proof of recovery of growth from lateral physis. Therefore, it is less likely that vascular insult from surgery leads to growth plate necrosis as one of the possible mechanisms suggested by Nanthan *et al.* [12].

When the growth is complete, valgus deformity would require supramalleolar osteotomy. Wiltse *et al.* [8] pointed out that a simple wedge resection will cause malalignment and prominent medial malleolus. We treated the valgus deformity in patient no. 2 with transverse osteotomy, varus and lateral shifting to avoid these problems. In addition, we created tibia–fibula synostosis above the syndesmotic joint by inserting a bridging bone graft and by temporary screw fixation to prevent possible recurrence. Treatment of pes planus and hindfoot valgus in patient no. 4 was performed by transfer of the flexor halucis to the tibialis posterior muscle and reduction and fusion of the talonavicular joint.

## Conclusion

This review has shown that resection of the mid shaft of the fibula for the purpose of a vascularized fibula graft,

leaving a 6 cm length of distal fibular stump in children younger than 6 years old, may give rise to abnormal growth of the distal tibial physis leading to valgus ankle. The entire proximal fibular resection for a similar purpose in a 6-year-old child may give rise to weakness of the tibialis posterior and hindfoot valgus.

## Acknowledgements

### Conflicts of interest

There are no conflicts of interest.

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